

Please replace the paragraph beginning at page 13, line 15 with the paragraph in Attachment 6A. The changes are shown in Attachment 6B.

Please replace the paragraph beginning at page 21, line 22 with the paragraph in Attachment 7A. The changes are shown in Attachment 7B.

Please replace the paragraph beginning at page 22, line 14 and the paragraph beginning at page 23, line 3 with those set forth in Attachment 8A. The changes are shown in Attachment 8B.

Please replace the paragraph beginning at page 24, line 6 with the paragraph in Attachment 9A. The changes are shown in Attachment 9B.

After the title, please insert the reference to prior applications set forth in Attachment 10.

#### In the Claims

Please amend claims 37, 40, 41, 46-48, 51, 60, 62 and 67 as set forth in Attachment 1A. The changes are shown in Attachment 1B.

Please cancel claim 55.

Please add new claims 69 and 70 as set forth in Attachment 11.

#### REMARKS

Claims 37-68 are pending in the present Application.

Applicants have amended the Specification as set forth in Attachments 2-10. These amendments claim the benefit of an earlier filed copending patent application, update the status of U.S. patent applications and correct typographical errors.

Newly added claim 69 is fully supported by the Specification at page 44, line 30. New claim 70 is fully supported by claim 37 as originally filed. Independent claims 37, 48 and 62 have been amended to specify that the metal foil (claim 37) and first metal layer (claims 48 and 62) are flexible. This limitation is fully supported by the Specification on page 7, line 25 through page 8, line 7. The term "flexible" is fully defined in the Specification at page 37, lines 2-4.

No new matter is added with this Amendment.

Claim 50 has been objected to as being in improper dependent form. This objection is made moot by the present Amendment and Applicants respectfully request that this objection be withdrawn.

Claims 40-41 and 48-61 have been rejected under 35 USC § 112, second paragraph, as being indefinite for failing to point out particularly and claim distinctly the subject matter which Applicants regard as their invention. This rejection is mooted by the present Amendment and Applicants respectfully request that this rejection be withdrawn.

Claims 37-61 have been rejected under 35 USC § 103(a) as being unpatentable over Lauffer et al. (U.S. 5,027,253) in view of Fischer (U.S. 4,996,097). Applicants respectfully traverse.

Applicants invention is directed to a structure suitable for forming a thin layer capacitor comprising a *flexible* metal foil and a dielectric material *deposited* on the metal foil where the dielectric material has a thickness of from about 0.03 to about 2 microns. The key to Applicant's invention is that the thin dielectric material is deposited on a flexible metal foil.

In the Lauffer patent, the first step is the circuitization of a conductive plane. See column 9, lines 27-32. In order to perform such circuitization, the conductive plane must be on a substrate or support. In fact, the Lauffer patent discloses that the conductive plane is a ground plane or core, or a power plane or core. See column 9, lines 30-32. All of the conductive plane examples of Lauffer have a circuitized layer on a support. None of these provide for flexible structures as required by Applicants' claims. The material of the Lauffer patent must be prepared this way as the deposition of thin dielectric films on flexible metal foils to form structures suitable for use in capacitors was unknown prior to Applicants' invention.

Fischer fails to fill the deficiencies of Lauffer et al. The Fischer patent discloses forming a high capacitance laminate by laminating a filled polymer dielectric to a metal foil. No other dielectric materials are disclosed or suggested in this patent. Additionally, this patent only

discloses a lamination method for forming the capacitance material. In contrast to Fischer, Applicants' dielectric material is not laminated to the flexible metal foil, rather Applicants' dielectric material is deposited on the metal foil. Fischer is further distinguished from Applicants' invention as the dielectric of Fischer is filled with a high dielectric constant particulate. See column 2, lines 30-32. Such particulate has an average size of less than 20  $\mu\text{m}$ , meaning there will be particulates having a size of  $> 20$   $\mu\text{m}$ . Such sizes are well above (by an order of magnitude) the thickness of Applicants' dielectric layer. Also, the pressing and lamination step of Fischer requires pressures of 1000 psi in a vacuum press at about  $350^{\circ}\text{C}$ . Such conditions cannot be used to prepare the structures claimed by Applicants.

There is nothing in these references that would lead one skilled in the art to combine them. Even if one were to combine these references one would at best laminate the filled polymer dielectric of Fischer to the circuitized ground plane or power plane of Lauffer. There is nothing in this combination that discloses or suggests Applicants claimed structure having a flexible metal foil and a thin ( $\leq 2$   $\mu\text{m}$ ) dielectric material layer. Applicants submit that the Examiner has not made out a prima facie case of obviousness and respectfully request that this rejection be withdrawn.

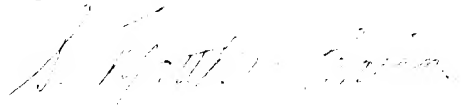
Claims 62-67 have been rejected under 35 USC  $\S$  103(a) as being unpatentable over Elderbaum (U.S. 4,008,514). Applicants respectfully traverse.

In the Elderbaum patent, a first pattern of electrodes is defined on a release surface. A thin layer of green ceramic is then cast on the pattern of electrodes. See column 1, lines 31-35. In contrast to Elderbaum, Applicants claims require an unpatterned metal layer. Elderbaum neither teaches nor suggests casting a green ceramic dielectric onto an unpatterned metal layer. Firing is subsequently required to convert the ceramic from a green state to a monolithic structure suitable for use as a capacitor. See column 3, lines 37-48. According to Elderbaum, such firing is performed after a second metal layer is applied to the green ceramic, it is removed from the support sheet and individual capacitors are cut. The desired dielectric material of Elderbaum is only obtained after such firing of the green ceramic. Applicants' structures are formed by directly depositing a desired dielectric on the metal foil. Elderbaum fails to disclose or suggest a

structure having an unpatterened first metal layer on a support sheet and a desired dielectric on the first metal layer. Applicants submit that the Examiner has not made out a prima facie case of obviousness and respectfully request that this rejection be withdrawn.

Based on the forgoing, Applicants respectfully request favorable reconsideration in the form of a notice of allowance.

Respectfully submitted,



S. Matthew Cairns, Ph.D.

Attorney for Applicant

Registration No. 42,378

Telephone No: (508) 229-7545

Facsimile No.: (508) 787-4730

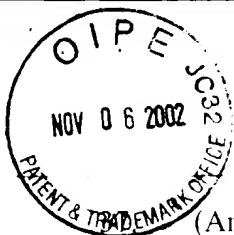
c/o EDWARDS & ANGELL

Dike, Bronstein, Roberts & Cushman IP Group

130 Water Street

Boston, MA

Date:



## ATTACHMENT 1A

C10 (Amended) A layered structure for forming a thin layer capacitor comprising a flexible metal foil formed of a metal selected from the group consisting of copper, zinc, nickel, iron, niobium, molybdenum, titanium, nickel/chromium alloy, iron/nickel/chromium alloy and aluminum, and a desired dielectric material deposited on a surface of the foil, wherein the dielectric material is a layer having a thickness of from about 0.03 to about 2 microns.

C11 40. (Amended) The layered structure according to Claim 37 further comprising a second metal layer deposited on said dielectric material layer.

41. (Amended) The layered structure according to Claim 40 wherein said foil is between about 12 and about 110 microns thick.

46. (Amended) The layered structure in accordance with Claim 37 wherein said metal foil surface has a roughness of at least about  $1.1 \text{ cm}^2/\text{cm}^2$ .

47. (Amended) The layered structure in accordance with Claim 37 wherein said dielectric material layer is lossy having an electrical conductivity value of from about  $10^{-1}$  to about  $10^{-5}$  amperes per  $\text{cm}^2$ .

C12 48. (Amended) A layered structure for acting as or forming at least one thin layer capacitor comprising, in sequence, a flexible first metal layer selected from the group consisting of copper, zinc, nickel, iron, niobium, molybdenum, titanium, nickel/chromium alloy, iron/nickel/chromium alloy and aluminum, a desired dielectric material deposited on a surface of the first metal layer and having a thickness of from about 0.03 to about 2 microns and a second metal layer and wherein the dielectric material comprises a cation material different from the metal from which the first metal layer is formed.

C13 51. (Amended) The layered structure of Claim 50 wherein said metal foil is selected from the group consisting of copper foil, nickel foil and aluminum foil.

C14 60. (Amended) The layered structure in accordance with Claim 48 wherein said first metal layer surface has a roughness of at least about  $1.1 \text{ cm}^2/\text{cm}^2$ .

C15 62. (Amended) A layered structure for forming a thin layer capacitor comprising:  
a flexible polymer support sheet,

C15  
(cont)  
an un-patterned flexible first metal layer formed on said flexible polymer support sheet, said first metal layer being release-able from said support sheet, the metal being selected from the group consisting of copper, zinc, nickel, iron, niobium, molybdenum, titanium, nickel/chromium alloy, iron/nickel/chromium alloy and aluminum,

a dielectric layer deposited on a surface of said un-patterned first metal layer between about 0.03 and about 2 microns thick, and

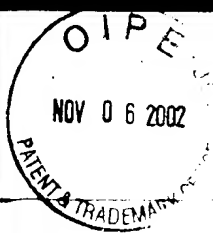
a second metal layer formed on said flexible polymer support sheet, the metal being selected from the group consisting of copper, zinc, nickel, iron, niobium, molybdenum, titanium, nickel/chromium alloy, iron/nickel/chromium alloy and aluminum, said second metal layer having an exposed surface.

C16  
67. (Amended) The layered structure in accordance with Claim 62 wherein said first metal layer surface has a roughness of at least about  $1.1 \text{ cm}^2/\text{cm}^2$ .



## ATTACHMENT 2A

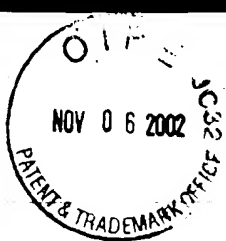
A preferred embodiment of the CCVD process is described in detail in U.S. Application No. 08/691,853 filed 2 August 1996, now U.S. Patent No. 5,997,956, issued December 7, 1999, the teachings of which are incorporated herein by reference. In accordance with that application, a CCVD produces vapor formed films, powders and nanophase coatings from near-supercritical liquids and supercritical fluids. Preferably, a liquid or liquid-like solution fluid containing chemical precursor(s) is formed. The solution fluid is regulated to near or above the critical pressure and is then heated to near the supercritical temperature just prior to being released through a restriction or nozzle which results in a gas entrained very finely atomized or vaporized solution fluid. The solution fluid vapor is combusted to form a flame or is entered into a flame or electric torch plasma, and the precursor(s) react to the desired phase in the flame or plasma or on the substrate surface. Due to the high temperature of the plasma much of the precursor will react prior to the substrate surface. A substrate is positioned near or in the flame or electric plasma, and a coating is deposited. Alternatively, the material formed can be collected as a nanophase powder.



## ATTACHMENT 3A

CCVD is a flame process which utilizes oxygen. While it may be possible using CCVD to deposit oxygen-reactive materials with CCVD by depositing in the reducing portions of the flame, a better technique for depositing oxygen reactive materials, such as nickel is a related process described in U.S. Patent Application No. 09/067,975, filed 20 April 1998, now U.S. Patent No. 6,368,665, issued April 9, 2002, the teachings of which are incorporated herein by reference.





#### ATTACHMENT 4A

A further advantage of CACCVD is its ability to coat substrates without needing additional energy supplied to the substrate. Accordingly, this system allows substrates to be coated which previously could not withstand the temperatures to which substrates were subjected by most previous systems. For instance, nickel coatings can be provided on polyamide sheet substrates without causing deformation of the substrate. Previously atmospheric pressure deposition techniques were unable to provide chemical vapor deposition of metallic nickel because of its strong affinity to oxygen, while vacuum processing of polyamide sheet substrates was problematic due to its outgassing of water and tendency toward dimensional instability when subjected to heat and vacuum.



## ATTACHMENT 5A

The substrate material should be capable of being rolled and should be available in many widths, and long lengths. Materials such as metals foils and polymers satisfy these needs while silicon does not. Silicon is easier to deposit on by most techniques because it is stiff, does not out-gas and is of small size. CCVD is able to coat the desired substrates with quality coatings.



## ATTACHMENT 6A

The present invention also provides a method where, during the exposing step, the substrate is cooled using a substrate cooling means. In a preferred embodiment, the substrate cooling means comprises a means for directing water onto the substrate. However, one of ordinary skill in the art would recognize that many other suitable cooling means could be used.



## ATTACHMENT 7A

Without wishing to be bound by theory, it is helpful to understand that the principle of the deposition technique of the present invention involves the finding that CVD is not limited to reactions at the surface. See Hunt, A. T., "Combustion Chemical Vapor Deposition, a Novel Thin Film Deposition Technique", Ph.D. Thesis Georgia Inst. of Tech, Atlanta, GA., (1993); Hunt, A. T., "Presubstrate Reaction CVD, and a Definition for Vapor", presented at the 13th Int. Conf. on CVD, Los Angeles, CA (1996), the contents of which are hereby incorporated by this reference. Reactions can occur predominately in the gas stream, but the resulting material which is deposited must be subcritical in size to yield a coating with vapor deposited microstructures. These observations demonstrate that a vapor is composed of individual atoms, molecules or nanoclusters which can be absorbed onto a substrate and readily diffused into lower energy sites or configurations. Thus the maximum cluster size must decrease with lower substrate temperatures as does the critical nucleus size. It is known by one of ordinary skill in the art that reagent clusters are left after vaporization of the solvents, and the cluster size is related to the reagent vapor pressure, initial droplet size and the solution concentration. Therefore, atomization of low vapor pressure reagents, which therefore do not gasify in the flame, must be very fine to form vapor.



## ATTACHMENT 8A

One preferred solvent and secondary solution fluid is propane, which is a gas at STP. However, it must be noted that many other solvent systems are operable. See, e.g., CRC Handbook of Chemistry and Physics, CRC Press, Boca Raton, Florida. Propane is preferred because of its low cost, its commercial availability, and its safety. Many low cost organometalics can be used in a predominately propane solution. To ease handling, the initial precursors can be dissolved in methanol, isopropanol, toluene or other solvents compatible with propane. This initial solution is then placed into a container into which liquid propane is added. Propane is a liquid at above only about 100 psi at room temperatures. The resulting solution has a much lower supercritical point than the initial solution which eases atomization by lowering the required energy input into the atomizer. Additionally, the primary solvent acts to increase the polar solubility of the propane, thus allowing higher solution concentrations for many reagents than would otherwise be achieved by propane alone. As a general rule, the polarity of the primary solvent should increase with increasing polarity of the solute (precursor). Isopropanol can thus aid in the solubility of a polar solute better than toluene. In some cases the primary solvent acts as a shield between the secondary solvent and a ligand on the solute. One example is the dissolution of platinum-acetylacetonate ( $\text{Pt}(\text{CH}_3\text{COCHCOCH}_3)_2$ ) in propane, where the weight ratios between precursor/primary solvent and primary solvent/secondary solvent can be higher than those required in other systems.

Ammonia has been considered and tested as a secondary solvent for the deposition of coatings and powders. While ammonia is an inexpensive solvent that is compatible with some nitrate based precursors, it is not easily usable with other secondary solvents and problems stem from the general aggressiveness of pure ammonia. The atomization properties of ammonia were tested without the addition of a precursor and the used pressure vessel was significantly attacked after the experiment even when an inert Type-316 stainless steel vessel was used. In contrast to hydrocarbon based solvents, ammonia also renders Buna-N and Viton gaskets useless after only a few minutes. Even with a suitable gasket material this is a problem since the desired coatings or powders usually must not contain traces of iron or other elements leached from the pressure vessel wall. However, there are materials, such as EPDM elastomer which may be used. Ni has been deposited from an ammonia-water mix with Ni-amine-nitrate formed precursor.



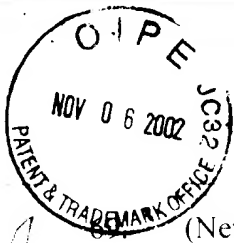
## ATTACHMENT 9A

Remote resistive heating uses a non-conducting restriction tube that is located inside an electrically heated tube. The non-conducting tube will fit tightly into the conductive tube.

Application of an electric current to the conductive tube heats that tube and energy is transferred into the inner, non-conductive restriction tube. This method requires larger heating currents compared to the directly-heated restrictive tube method and shows longer response times, which can be advantageous under certain conditions since the increased response time results in a high degree of thermal stability. On the other hand, pilot flame and laser heating use the energy of the pilot flame or laser light, respectively, to heat the restriction tube. This can be done in a directly heated setup where the tip of the restriction tube is subjected to the pilot flame or laser light or in an indirectly heated configuration where the larger outer tube is heated. Because the amount of energy that needs to be transferred into the solution is quite large, the heated tube will, preferably, have a thicker wall than in the case of direct electrical heating or remote electrical heating. Subjecting an outer tube to the pilot flame or laser light allows the use of a thin walled restriction tube.

## ATTACHMENT 10

This application is a divisional of copending application 09/198,285, filed on November 23, 1998, now U.S. Patent No. 6,207,522.



**ATTACHMENT 11  
NEWLY ADDED CLAIMS**

(New) The layered structure in accordance with Claim 48 wherein said first metal layer surface has a roughness of at least about  $2 \text{ cm}^2/\text{cm}^2$ .

70. (New) The layered structure in accordance with Claim 37 wherein said metal foil has an exposed surface.



**ATTACHMENT 1B**  
**VERSION SHOWING CHANGES MADE**

37. (Amended) A layered structure for forming a thin layer capacitor comprising a flexible metal foil formed of a metal selected from the group consisting of copper, zinc, nickel, iron, niobium, molybdenum, titanium, nickel/chromium alloy, iron/nickel/chromium alloy and aluminum, and a desired dielectric material deposited on a surface of the foil, wherein the dielectric material is a layer having a thickness of from about 0.03 to about 2 microns; ~~said metal foil having an exposed surface and said dielectric material layer having an exposed surface.~~
40. (Amended) The layered structure according to Claim 37 ~~said~~ further comprising a second metal layer is a metal layer deposited on said dielectric material layer.
41. (Amended) The layered structure according to Claim 40 wherein said foil is between about 12 and about 110 microns thick.
46. (Amended) The layered structure in accordance with Claim 37 wherein said ~~first metal layer has a foil surface~~ has a roughness on the side of said dielectric material layer of at least about  $1.1 \text{ cm}^2/\text{cm}^2$ .
47. (Amended) The layered structure in accordance with Claim 37 wherein said dielectric material layer is lossy having an electrical conductivity value of ~~from~~ from about  $10^{-1}$  to about  $10^{-5}$  amperes per  $\text{cm}^2$ .
48. (Amended) A layered structure for acting as or forming at least one thin layer capacitor comprising, in sequence, a flexible first metal layer selected from the group consisting of copper, zinc, nickel, iron, niobium, molybdenum, titanium, nickel/chromium alloy, iron/nickel/chromium alloy and aluminum, a desired dielectric material deposited on a surface of the first metal layer and having a thickness of from about 0.03 to about 2 microns and a second metal layer and wherein the dielectric material ~~contains a cation other than that of~~ comprises a cation material different from the metal from which the first metal foil layer is formed, and a second metal layer, ~~said first and second metal layers each having an exposed surface.~~
51. (Amended) The layered structure of Claim ~~48-50~~ wherein said metal foil is selected from the group consisting of copper foil, nickel foil and aluminum foil.

60. (Amended) The layered structure in accordance with Claim 48 wherein said first metal layer ~~has a surface~~ has a roughness on the side of said dielectric material layer of at least about  $1.1 \text{ cm}^2/\text{cm}^2$ .

62. (Amended) A layered structure for forming a thin layer capacitor comprising:  
a flexible polymer support sheet,

an un-patterned flexible first metal layer formed on said flexible polymer support sheet, said first metal layer being release-able from said support sheet, the metal being selected from the group consisting of copper, zinc, nickel, iron, niobium, molybdenum, titanium, nickel/chromium alloy, iron/nickel/chromium alloy and aluminum,

a dielectric layer ~~formed~~ deposited on a surface of said un-patterned first metal layer between about 0.03 and about 2 microns thick, and

a second metal layer formed on said flexible polymer support sheet, the metal being selected from the group consisting of copper, zinc, nickel, iron, niobium, molybdenum, titanium, nickel/chromium alloy, iron/nickel/chromium alloy and aluminum, said second metal layer having an exposed surface.

67. (Amended) The layered structure in accordance with Claim 62 wherein said first metal layer ~~has a surface~~ has a roughness on the side of said dielectric material layer of at least about  $1.1 \text{ cm}^2/\text{cm}^2$ .



**ATTACHMENT 2B**  
**VERSION SHOWING CHANGES MADE**

A preferred embodiment of the CCVD process is described in detail in U.S. Application No. 08/691,853 filed 2 August 1996, now U.S. Patent No. 5,997,956, issued December 7, 1999, the teachings of which are incorporated herein by reference. In accordance with that application, a CCVD produces vapor formed films, powders and nanophase coatings from near-supercritical liquids and supercritical fluids. Preferably, a liquid or liquid-like solution fluid containing chemical precursor(s) is formed. The solution fluid is regulated to near or above the critical pressure and is then heated to near the supercritical temperature just prior to being released through a restriction or nozzle which results in a gas entrained very finely atomized or vaporized solution fluid. The solution fluid vapor is combusted to form a flame or is entered into a flame or electric torch plasma, and the precursor(s) react to the desired phase in the flame or plasma or on the substrate surface. Due to the high temperature of the plasma much of the precursor will react prior to the substrate surface. A substrate is positioned near or in the flame or electric plasma, and a coating is deposited. Alternatively, the material formed can be collected as a nanophase powder.



**ATTACHMENT 3B**  
**VERSION SHOWING CHANGES MADE**

CCVD is a flame process which utilizes oxygen. While it may be possible using CCVD to deposit oxygen-reactive materials with CCVD by depositing in the reducing portions of the flame, a better technique for depositing oxygen reactive materials, such as nickel is a related process described in U.S. Patent Application No. 09/067,975, filed 20 April 1998, now U.S. Patent No. 6,368,665, issued April 9, 2002, the teachings of which are incorporated herein by reference.



**ATTACHMENT 4B**  
**VERSION SHOWING CHANGES MADE**

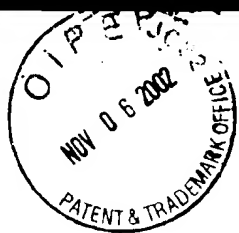
A further advantage of CACCVD is its ability to coat substrates without needing additional energy supplied to the substrate. Accordingly, this system allows substrates to be coated which previously could not withstand the temperatures to which substrates were subjected by most previous systems. For instance, nickel coatings can be provided on polyamide sheet substrates without causing deformation of the substrate. Previously atmospheric pressure deposition techniques were unable to provide chemical vapor deposition of metallic nickel because of its strong affinity to oxygen, while vacuum processing of polyamide sheet substrates was problematical due to its outgassing of water and tendency toward dimensional instability when subjected to heat and vacuum.

0000  
NOV 06 2002  
U.S. PATENT & TRADEMARK OFFICE



**ATTACHMENT 5B**  
**VERSION SHOWING CHANGES MADE**

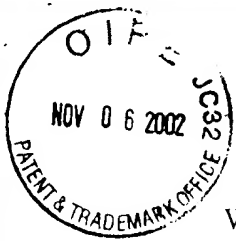
The substrate material should be ~~thing~~-capable of being rolled and should be available in many widths, and long lengths. Materials such as metals foils and polymers satisfy these needs while silicon does not. Silicon is easier to deposit on by most techniques because it is stiff, does not out-gas and is of small size. CCVD is able to coat the desired substrates with quality coatings.



**ATTACHMENT 6B**  
**VERSION SHOWING CHANGES MADE**

The present invention also provides a method where, during the exposing step, ~~cooling~~ the substrate is cooled using a substrate cooling means. In a preferred embodiment, the substrate cooling means comprises a means for directing water onto the substrate. However, one of ordinary skill in the art would recognize that many other suitable cooling means could be used.

**ATTACHMENT 7B**  
**VERSION SHOWING CHANGES MADE**



Without wishing to be bound by theory, it is helpful to understand that the principle of the deposition technique of the present invention involves the finding that CVD ~~is~~is not limited to reactions at the surface. See Hunt, A. T., "Combustion Chemical Vapor Deposition, a Novel Thin Film Deposition Technique", Ph.D. Thesis Georgia Inst. of Tech, Atlanta, GA., (1993); Hunt, A. T., "Presubstrate Reaction CVD, and a Definition for Vapor", presented at the 13th Int. Conf. on CVD, Los Angeles, CA (1996), the contents of which are hereby incorporated by this reference. Reactions can occur predominately in the gas stream, but the resulting material which is deposited must be subcritical in size to yield a coating with vapor deposited microstructures. These observations demonstrate that a vapor is composed of individual atoms, molecules or nanoclusters which can be absorbed onto a substrate and readily diffused into lower energy sites or configurations. Thus the maximum cluster size must decrease with lower substrate temperatures as does the critical nucleus size. It is known by one of ordinary skill in the art that reagent clusters are left after vaporization of the solvents, and the cluster size is related to the reagent vapor pressure, initial droplet size and the solution concentration. Therefore, atomization of low vapor pressure reagents, which therefore do not gasify in the flame, must be very fine to form vapor.





**ATTACHMENT 8B**  
**VERSION SHOWING CHANGES MADE**

One preferred solvent and secondary solution fluid ~~which~~ is propane, which is a gas at STP. However, it must be noted that many other solvent systems are operable. See, e.g., CRC Handbook of Chemistry and Physics, CRC Press, Boca Raton, Florida. Propane is preferred because of its low cost, its commercial availability, and its safety. Many low cost organometalics can be used in a predominately propane solution. To ease handling, the initial precursors can be dissolved in methanol, isopropanol, toluene or other solvents compatible with propane. This initial solution is then placed into a container into which liquid propane is added. Propane is a liquid at above only about 100 psi at room temperatures. The resulting solution has a much lower supercritical point than the initial solution which eases atomization by lowering the required energy input into the atomizer. Additionally, the primary solvent acts to increase the polar solubility of the propane, thus allowing higher solution concentrations for many reagents than would otherwise be achieved by propane alone. As a general rule, the polarity of the primary solvent should increase with increasing polarity of the solute (precursor). Isopropanol can thus aid in the solubility of a polar solute better than toluene. In some cases the primary solvent acts as a shield between the secondary solvent and a ligand on the solute. One example is the dissolution of platinum-acetylacetonate ( $\text{Pt}(\text{CH}_3\text{COCHCOCH}_3)_2$ ) in propane, where the weight ratios between precursor/primary solvent and primary solvent/secondary solvent can be higher than those required in other systems.

Ammonia has been considered and tested as a secondary solvent for the deposition of coatings and powders. While ammonia is an inexpensive solvent that is compatible with some nitrate based precursors, it is not easily usable with other secondary solvents and problems stem from the general aggressiveness of pure ammonia. The atomization properties of ammonia were tested without the addition of a precursor and the used pressure vessel was significantly attacked after the experiment even when an inert Type-316 stainless steel vessel was used. In contrast to hydrocarbon based solvents, ammonia also renders Buna-N and Viton gaskets useless after only a few minutes. Even with a suitable gasket material this is a problem since the desired coatings or powders usually must not contain traces of iron or other elements leached from the pressure vessel wall. However, there are materials, such as EPDM elastomer which may be used. Ni has been deposited from ~~a~~an ammonia-water mix with Ni-amine-nitrate formed precursor.



**ATTACHMENT 9B**  
**VERSION SHOWING CHANGES MADE**

Remote resistive heating uses a non-conducting restriction tube that is located inside an electrically heated tube. The non-conducting tube will fit tightly into the conductive tube. Application of an electric current to the conductive ~~type~~tube heats that tube and energy is transferred into the inner, non-conductive restriction tube. This method requires larger heating currents compared to the directly-heated restrictive tube method and shows longer response times, which can be advantageous under certain conditions since the increased response time results in a high degree of thermal stability. On the other hand, pilot flame and laser heating use the energy of the pilot flame or laser light, respectively, to heat the restriction tube. This can be done in a directly heated setup where the tip of the restriction tube is subjected to the pilot flame or laser light or in an indirectly heated configuration where the larger outer tube is heated. Because the amount of energy that needs to be transferred into the solution is quite large, the heated tube will, preferably, have a thicker wall than in the case of direct electrical heating or remote electrical heating. Subjecting an outer tube to the pilot flame or laser light allows the use of a thin walled restriction tube.